Smart Surveillance and Sensor System for Child Safety

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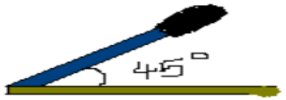
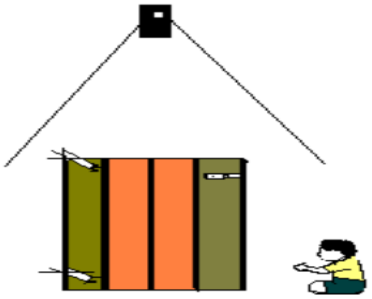
INTRODUCTION

- Enhancing home safety with an innovative technique.





PROBLEM STATEMENT:

The main problems I am addressing here are –

- Detect the presence of a being at the doorway.
- Distinguish between adults and babies based on height.
- Trigger appropriate actions based on the detection results.

- This solution has two parts an Android application with real-time human detection and a sensor-based doorway monitoring mechanism. The app detects human presence using advanced computer vision techniques, while Raspberry Pi-connected sensors differentiate between adults and infants.

MOTIVATION

- This graph indicates the Average Annual number of stair-related injuries VS Age of the person.

BACKGROUND

Let's discuss the basic concepts used in implementing this project –
- Computer Vision
- Object detection
- Raspberry Pi & Obstacle detection sensor (Architecture and PIN diagram)

Computer Vision

- Computers interpret and process visual information from the world.
- Applications – image recognition, Object detection, facial recognition and many more

OpenCV

- OpenCV is an open-source computer vision and machine learning software library.
- Provides tools for image processing, video capture, and analysis, including features like object detection, face recognition, and motion tracking.

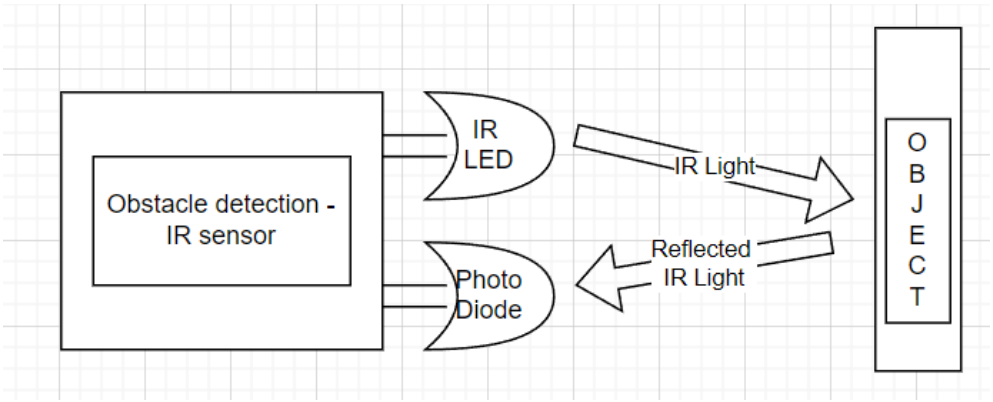
Raspberry PI 3 model B+

It’s a Single board computer with more functionalities like touch screen display, Bluetooth etc
Specifications -

- Memory - 1GB
- 40-pin GPIO header
- MicroSD card slot for loading operating systems and data storage
- Full-size HDMI port
- Display
- Power – 5V and 2.5V input
- 4 USB ports
- Bluetooth

Obstacle-detection IR sensor

- The **IR LED** emits infrared light, which is invisible to the human eye. When this light hits an object, it is reflected and detected by the photodiode.
- Sensor processes this information to determine the presence of any object.
- IR light has a longer wavelength around 850nm to 950nm, which is greater than normal light(380nm – 700nm)



Photodiode is a semiconductor device that converts light into electrical current.

- Detects IR light specifically the wavelength emitted by it.

Conversion to Electrical current -

When the IR light hits the diode it generates current proportional to the intensity of the light.

$$I \propto I_{\text{light}}$$

INITIAL IDEA AND WORK

- Previous attempts to enhance home safety mainly involved detecting the distance and speed of the humans detected using the MobileNet SSD model using a Phone camera.
- After the distance is detected with the help of assuming the following, adults and babies can be differentiated.

- camera positioned at a height of 9 feet from the ground.
- Threshold distance = 6 ft from Camera
- If detected distance > threshold, BABY.
- Else, if the distance is in 6ft range, ADULT.

Detecting the distance from desktop camera

- And for calculating the distance of the person from the desktop camera

$$\text{distance} = \frac{\text{focal\_length}}{\text{height}}$$

Distance
3.184713
3.861004
3.610108
3.831418
4.385965
4.149378
2.403846
4.065041
4.255319
3.508772
3.690037
3.937008
3.759398
3.787879
3.759398
3.484321
4.608295
3.484321

Calculated metrics for entrees of distance data

Actual distance is 5ft.

```
In [ ]:
import numpy as np

# Distance measurements
distances = [
    #distance data list
]

# Thresholds for classification
lower_bound = 4.5
upper_bound = 5.5

# Classify distances
tp = sum(lower_bound <= d <= upper_bound for d in distances)
fp = sum(d < lower_bound or d > upper_bound for d in distances)
fn = 0  # As there are no true values to compare against, FN will be 0
tn = 0  # As there are no true values to compare against, TN will be 0

# Calculate metrics
accuracy = (tp + tn) / (tp + tn + fp + fn)
precision = tp / (tp + fp)
recall = tp / (tp + fn) if tp + fn != 0 else 0
f1_score = 2 * (precision * recall) / (precision + recall) if precision + recall != 0 else 0

accuracy, precision, recall, f1_score
```

Results:

Accuracy: 0.0693069306931
Precision: 0.0693069306931
Recall: 1.0
F1_score: 0.12962962962

- Since all measurements are outside the threshold range of 4.5 to 5.5 feet, the precision, recall, and F1_score are zero, indicating no true positives and only false positives in the data. The experiment does not appear to be accurate according to these metrics.

Drawbacks

- However, the reliance on a single camera led to inaccuracies, as precise distance measurement typically requires stereo cameras. This inadequacy resulted in incorrect classifications and unreliable notifications, highlighting the need for a more robust solution.

APPROACH EVOLUTION

- Realizing the inadequacy of a single-camera setup for accurate distance measurement, an alternative method was explored to enhance child safety through human detection and differentiation between adult and baby.
- This exploration led to considering an Internet of Things (IoT) based approach using sensors. The system uses obstacle detection sensors with a Raspberry Pi, enabling precise differentiation between adults and infants. This sensor-based approach promises improved accuracy and reliability, addressing the shortcomings of the earlier camera-based distance prediction system.

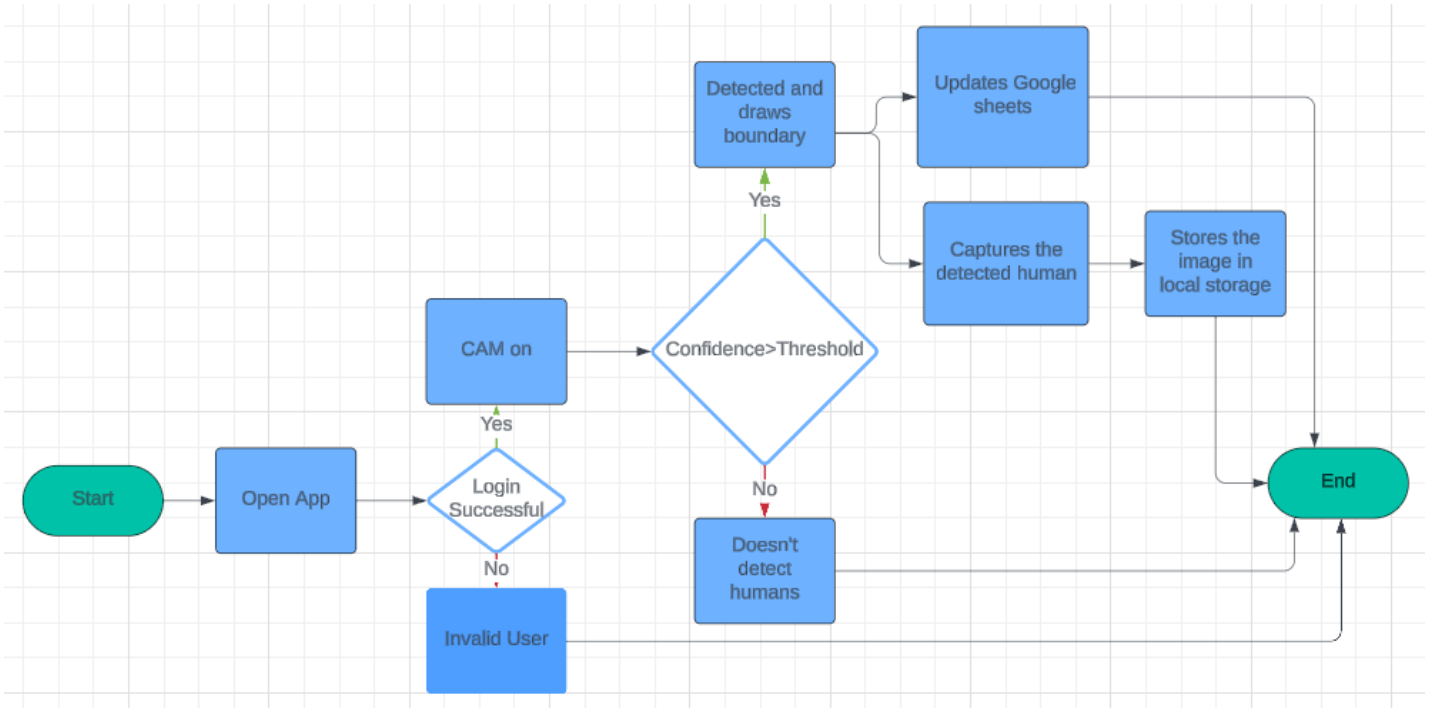
METHODOLOGY

- The proposed approach has an Android application for real-time human detection using OpenCV and MobileNet SSD with a Raspberry Pi-based obstacle detection system using IR sensors to enhance home safety. This system differentiates between adults and infants based on sensor detection and sends appropriate notifications, ensuring accurate and timely detection of individuals near the doorway.

SMART SURVEILLANCE SYSTEM USING OPENCV AND ANDROID STUDIO

- Setup and Security
- Real- Time for Human Detection
- Image capturing and updating Google sheets accordingly
- Storage of the image in the local

FLOWCHART OF SMART SURVEILLANCE SYSTEM USING OPENCV AND ANDRIOD STUDIOS



Google Sheets – Time stamp, Confidence , Distance

	A	B	C
1	Time stamp	Confidence	Distance
556	6/15/2024 2:42:04	0.81999	3.184713
557	6/15/2024 2:42:04	0.832948	3.861004
558	6/15/2024 2:42:05	0.84609	3.610108
559	6/15/2024 2:42:05	0.837846	3.831418
560	6/15/2024 2:42:05	0.825239	4.385965
561	6/15/2024 2:42:05	0.874494	4.149378
562	6/15/2024 2:42:06	0.898877	2.403846
563	6/15/2024 2:42:06	0.804521	4.065041
564	6/15/2024 2:42:06	0.814772	4.255319
565	6/15/2024 2:42:06	0.862466	3.508772
566	6/15/2024 2:42:07	0.899411	3.690037
567	6/15/2024 2:42:07	0.856651	3.937008
568	6/15/2024 2:42:07	0.814936	3.759398
569	6/15/2024 2:42:07	0.901329	3.787879
570	6/15/2024 2:42:07	0.902689	3.759398
571	6/15/2024 2:42:07	0.980626	3.484321
572	6/15/2024 2:42:07	0.903611	4.608295
573	6/15/2024 2:42:08	0.838951	3.484321

Only detects when
ClassId = 15

Confidence >Threshold

Threshold = 80

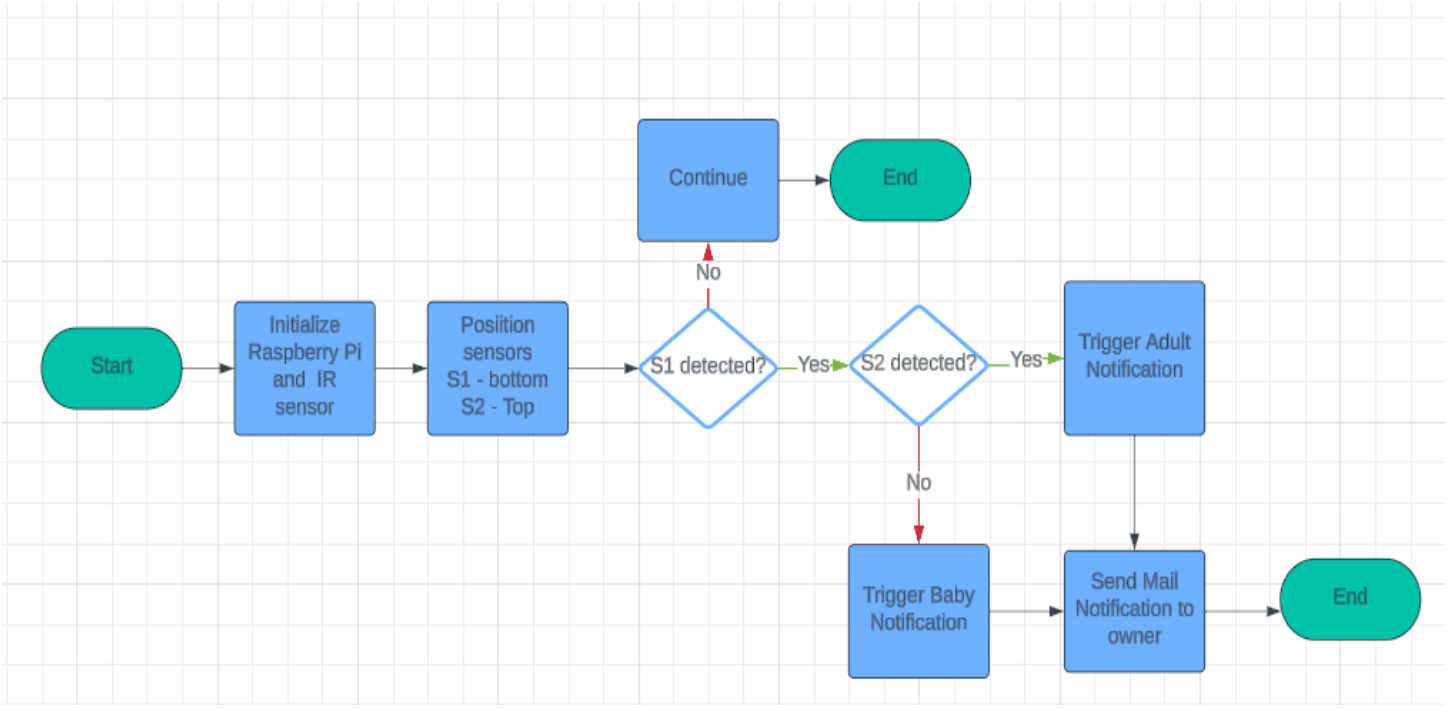
Captured Image storage

- Simultaneously when a bounding box is created the frame is captured continuously and stored in local storage.

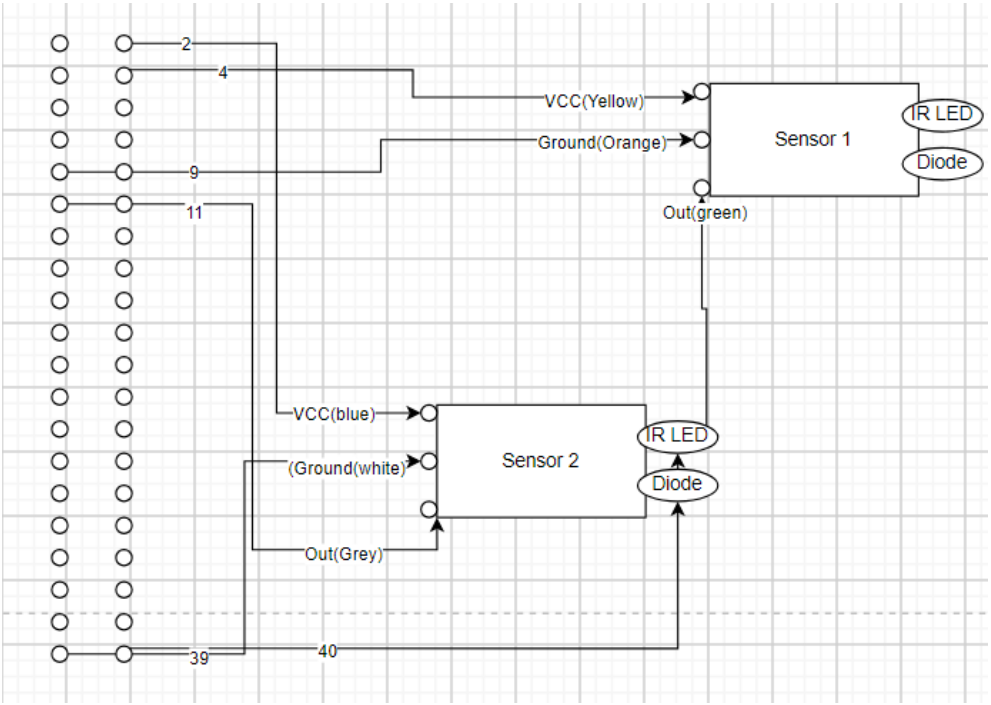
SENSOR-BASED OBSTACLE DETECTION SYSTEM

- System Setup and Implementation
- Detection and sending Notification
- Real-Time Processing

FLOWCHART OF SENSOR-BASED OBSTACLE DETECTION SYSTEM



Connecting Raspberry Pi and Obstacle detecting IR Sensor – System Setup and Implementation



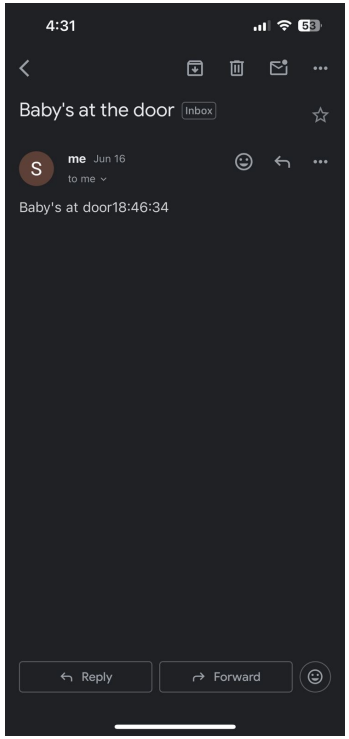
Sensor 1

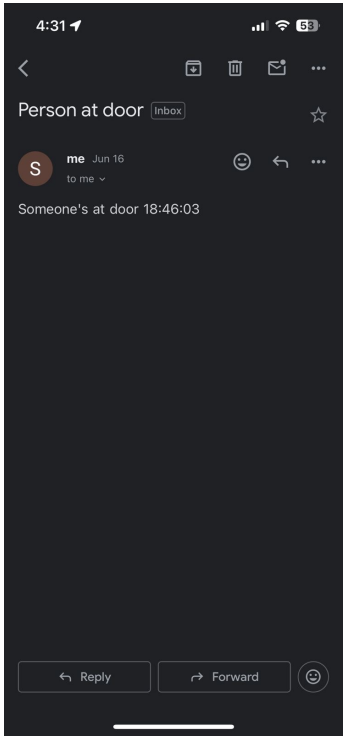
- Power - 4
- Ground - 9
- Out – 40

Sensor 2

- Power - 2
- Ground -39
- Out -11

Trigger Alerts





- When both of the sensors detect - It means a Person is at the door and triggers a notification with the same message.
- While, when only the bottom sensor detects, it triggers a message saying baby's at the door.

Accuracy of detections by sensors 1 and 2

Bottom Sensor	Top Sensor	Actual Detection	True/False
1	0	Baby's at the door	TRUE
1	0	Baby's at the door	TRUE
1	0	Baby's at the door	TRUE
1	1	Baby's at the door	FALSE
1	1	Person's at the door	TRUE
1	1	Person's at the door	TRUE
1	1	Person's at the door	TRUE
0	1	Someone's at the door	TRUE
0	1	Someone's at the door	TRUE
0	1	Someone's at the door	TRUE
0	0	Someone's at the door	FALSE
0	0	No alert	TRUE
0	0	No alert	TRUE
0	0	No alert	TRUE
0	0	No alert	TRUE
1	0	Baby's at the door	TRUE
1	0	Baby's at the door	TRUE
1	0	Baby's at the door	TRUE
0	1	Baby's at the door	FALSE
0	1	Someone's at the door	TRUE
0	1	Someone's at the door	TRUE
1	1	Someone's at the door	TRUE
1	1	Person's at the door	TRUE

Here the sleep time is set to 15 secs.
For each 15 seconds the sensors start detecting again.
Bottom sensor – S1
Top sensor – S2

Accuracy = (43/50)*100
= 86%

Accuracy Analysis

- **Detection Lag and Power Fluctuations**: Time lag and power fluctuations cause intermittent detection failures and inaccurate alerts.
- **Sleep Time and Storage Issues**: Longer sleep time causes delayed detection, while shorter sleep time leads to storage problems due to continuous alerts.

DRAWBACKS

- Depends on predefined height ranges.
- Environmental sensitivity – Light and weather constraints when located outdoors.
- IR sensors used here have a very small detection 3-4 inc range and only detect in the line of sight, which is a limitation for distance measurement.
- Only detects in the line of sight, which means only detects the person among many who is in its line.

AREAS OF IMPROVEMENT AND FUTURE SCOPE

- Multiple User Login feature in Android studio
- Integration of the surveillance smart system and sensor-based Obstacle detection system
- Enhanced Notification system by giving captured shots from the camera and live streaming.
- Stereo Camera set up for distance and velocity calculations
- Automatic Door lock and unlock system.

CONCLUSION

- The project effectively implements an Android application for real-time human detection and a sensor-based obstacle detection system, providing a simple and good solution for monitoring and controlling home access points.
- The system contributes significantly to enhancing safety for children and all age groups within residential environments.
- There is a good scope for improving this system for real-time usage for houses, Play areas, schools, offices, etc by adding different functionalities and using different technologies and Features.

THANK YOU